FISHERY RESEARCH
GALVESTON BIOLOGICAL LABORATORY

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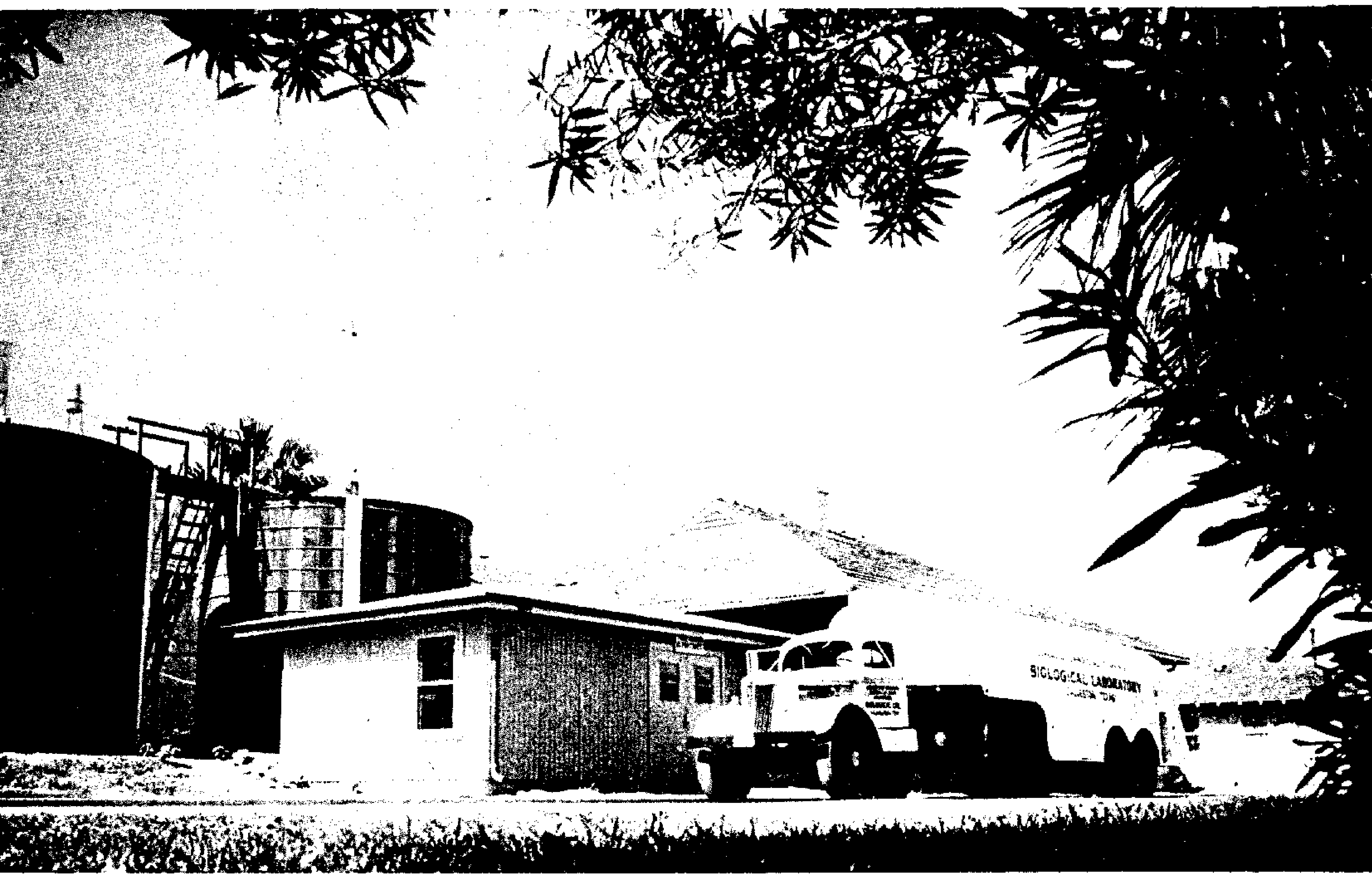

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

CIRCULAR 129

Shrimp Physiology

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During the past year additional specimens of both white and brown shrimp have been tested to determine oxygen requirements. They were selected for sex and size and included two extremely large white shrimp a female of 51.1 g. and a male of 42.6 g. The brown shrimp were smaller but included a large number of males to complete the picture of size and sex in relation to oxygen consumption.

Accurate records of molting in individual shrimp have been maintained. At least 4 animals have been held through 10 molts or more. Of these individuals one male white shrimp was found to increase in carapace length only 1.8 mm. (21.4 to 23.2) in a $7\frac{1}{2}$-month period (13 molts). In a second male the carapace increased 3.1 mm. (22.5 to 25.6) in a $5\frac{1}{2}$-month period (in which the animal molted 11 times). More rapid growth was recorded in two brown shrimp. One female with an original carapace length of 25.3 mm. increased 1.9 mm. in 4 months (6 molts), and a male with original carapace 19.8 mm. increased 3.1 mm. in only 3 months. This latter animal also increased in weight from 5.0 to 9.2 g. during 5 months in the laboratory. This group of animals, held for a long period in the laboratory, was then retested to determine the oxygen consumption. In all cases there was a significant decrease in oxygen consumption per gram (as much as 0.1 ml. oxygen per gram per hour). This was not entirely attributable to increase in size since the values for the "held" animals were significantly lower than those for other animals of the same sizes.

Individual specimens of *Trachypeneus similis* and *Squilla mantis* were also tested. Both of these animals used less oxygen than either the brown or the white shrimp. The *S. mantis* tested used about half as much oxygen per hour as a brown shrimp of similar size (1.4 ml. per hour for the 17 g. *Squilla*; 2.6 ml. per hour for the 20 g. *P. aztecus*). It is true that *Squilla* has more of its body weight as exoskeleton than does the shrimp, but even after discounting this, Squilla appears to metabolize more slowly. All data on both white and brown shrimp are being analyzed in preparation for a final report.

Nutritional studies have attempted to define mineral and vitamin requirements of two common species of shrimp. All experiments were carried out in recirculating artificial sea water (see tables). The earliest experiments indicated the importance of the calcium ion, for reduction of calcium below 25 percent that of normal sea water caused test shrimp to die within 30 hours. For this reason, the calcium concentration was increased above that in normal sea water.

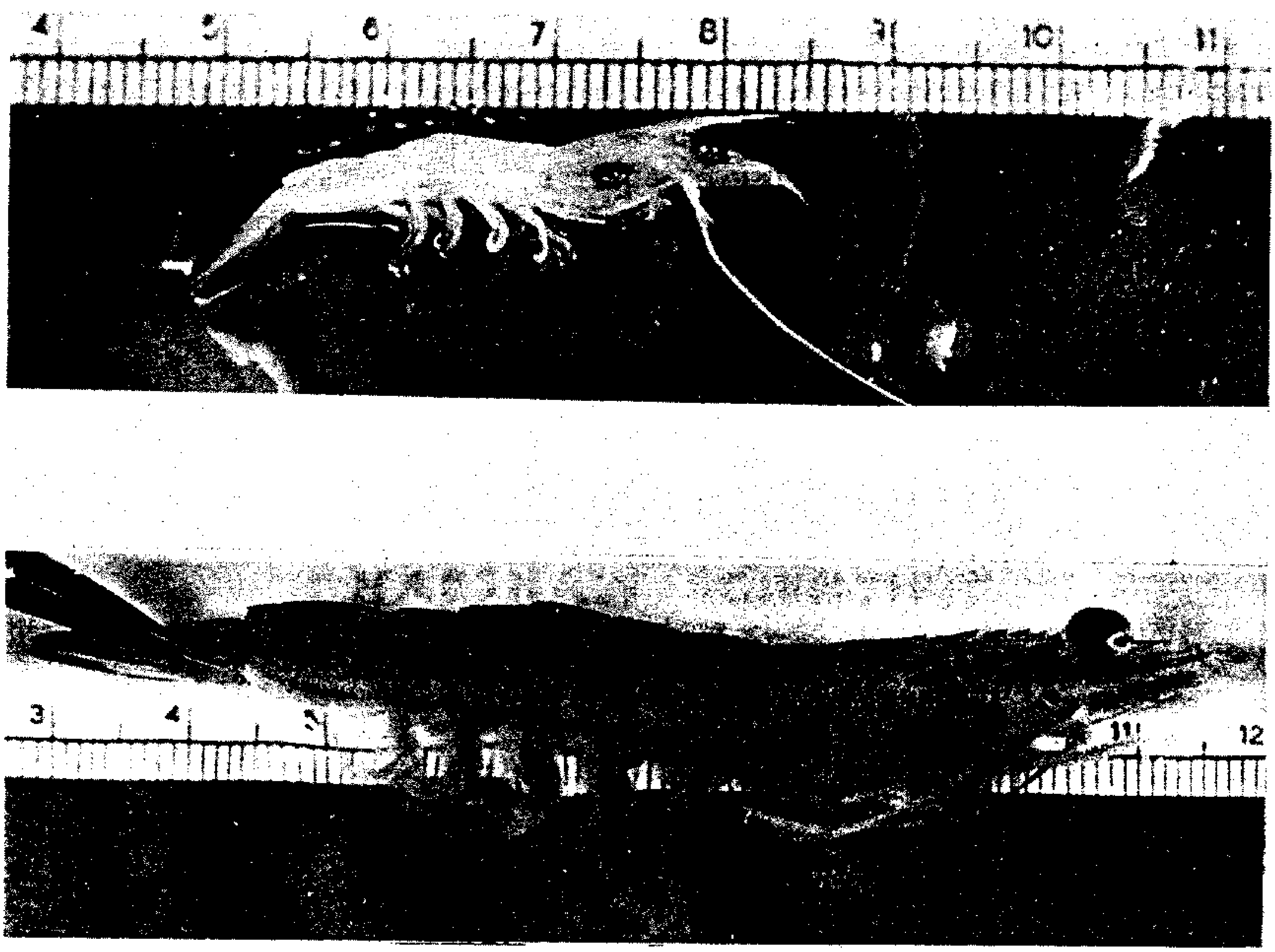
Artificial sea water (modified McClendon)

Sodium chloride	26.7 g.	
Magnesium chloride	2.26 g.	
Magnesium sulfate	3.25 g.	
Calcium chloride	1.71 g.	
Potassium chloride	0.72 g.	
Potassium iodide	1.0 mg.	
Trace metals mixture U-II	20 ml.	
Ferric chloride		1 mg.
Cupric chloride		1 mg.
Manganous chloride		10 mg.
Zinc chloride		5 mg.
Nickel chloride		1 mg.
Aluminum chloride		5 mg.
Cobalt chloride		5 mg.
Rubidium chloride		10 mg.
Barium chloride		1 mg.
Selenous acid		5 mg.
Ammonium vanadate		1 mg.
Titanium oxide		5 mg.
Zirconyl chloride		5 mg.
Potassium dichromate		5 mg.
Sodium molybdate		5 mg.
Boric acid		5 mg.
Cesium chloride		5 mg.
Cerium ammonium nitrate		1 mg.
Cadmium chloride		1 mg.
Stannic chloride		1 mg.
Ruthenium chloride		1 mg.
EDTA		150 mg.
Water to make		1,000 ml.
Distilled water to make	1,000 ml.	

Artificial diet

Casein	55 g.	
Gelatin	15 g.	
Hydrogenated fat (Crisco)	9 g.	
Dextrin	8 g.	
Vitamin mix	9 g.	
Alphacel		100 g.
Riboflavin		100 mg.
Pyridoxine		20 mg.
Choline chloride		1600 mg.
Nicotinic acid		200 mg.
Calcium pantothenate		100 mg.
Inositol		800 mg.
Biotin		2 mg.
Folic acid		6 mg.
Ascorbic acid		400 mg.
Thiamine		44 mg.
B_{12}		2 mg.
Alpha-tocopherol		40 mg.
Menadione		8 mg.
Beta-Carotene		20 mg.
Activated 7-dehydro cholesterol		4 mg.
Tryptophan		2 g.
DL-Methionine		4 g.
Mineral mix	4 g.	
USP Salt Mixture No. 2		100 g.
Aluminum chloride		15 mg.
Zinc sulfate		300 mg.
Cupric chloride		10 mg.
Manganous sulfate		80 mg.
Potassium iodide		50 mg.
Cobalt chloride		100 mg.
Water	200-250 ml.	

Comparisons of *P. setiferus* fed the artificial diet with those fed a variety of natural foods (liver, shrimp, oatmeal, and wheat germ) indicated that the animals fed artificial food had only a slightly increased laboratory life span. Of more significance was the decrease in frequency of the pathological condition shown in the figures. Fifty percent of the animals fed natural foods developed these dark, blistered areas on the ventral portion of the carapace; less than half as many animals fed the artificial food showed the change. Microscopic examination of this lesion showed it to be between the layers of the carapace itself--a dark fluid-filled blister which did not harden after the completion of the molt. Animals usually died within 24 hours after the development of the blister. The lesion was found in both *P. setiferus* and *P. aztecus*, but it occurred with less frequency in *P. aztecus*.



White and brown shrimp showing a dark blister on the ventral area of the carapace.

The latter observation may support the belief that *P. aztecus* as a species is hardier than *P. setiferus*. Further evidence may be adduced from experiments in which both species were tested simultaneously. Brown shrimp completed more successful molts (at *least* two, often three) and survived longer (up to 28 days) in artificial sea water than did white shrimp. However, no significant growth was found in either species. In neither species did percent survival approach that of animals fed the artificial diet but held in recirculating natural sea water. Apparently some compounds that may have some influence upon molting are still lacking from the artificial medium, this being indicated by the lesion already described and by a second lesion in which the most ventral portion of the carapace did not harden nor apply closely to the body so that the animal appeared to have "wings." The second type, more common in the brown than in the white shrimp, was not immediately fatal. Other apparent molting disorders, or indications of abnormal stress, occurred. Many of the animals in molt were unable to shed the carapace. Whether this was caused by general weakness or lack of a specific compound is unknown. It should be noted that the test animals lost appetite and became somewhat sluggish after several days in the laboratory. It may be concluded that at present we are unable to raise shrimp satisfactorily in artificial sea water, even when the animals are supplied with trace elements and essential vitamins.